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Asbestos in Public and Commercial Buildings:

A Literature Review and Synthesis of Current Knowledge

HEI·AR

Health Effects Institute - Asbestos Research

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The Health Effects Institute-Asbestos Research (HEI-AR) is an independent, non-profit organization formed recently to support research to determine the airborne exposure levels prevalent in buildings, to characterize peak exposures and their significance, and to evaluate the effectiveness of asbestos management and abatement strategies in a scientifically meaningful manner. HEI-AR is organized to gather and to generate reliable and objective information, and is supported jointly by the Environmental Protection Agency and a broad range of private parties that have an interest in asbestos. The congressional mandate under which HEI-AR now operates specifies that the HEI-AR's research "effort shall in no way be construed to limit or alter EPA's authority or obligation to proceed with rulemakings and to issue rules as necessary."

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useful additional information about the potential source and state of aggregation of the asbestos fibers and structures.

The indirect method has an advantage in that the very small amounts of asbestos present in environmental samples can be concentrated during the sample preparation by removing the organic and soluble particulates. Additional treatment such as acid washing can be used to remove carbonate particles and other acid-soluble particles (for example, limestone). Thus, greater filter loadings and better analytical sensitivity can be obtained than with the direct analysis, based on the same area being examined during the TEM analysis. The degree to which the sample can be concentrated, depends on the types of particles collected. It is the effects of these additional preparation steps which may remove the matrix material in which the asbestos is embedded or encapsulated, or release asbestos due to mechanical break-up of ACM debris, which result in some of the differences. In addition, depending on the conditions of preparation, indirect methods may result in longitudinal splitting and separation of the chrysotile fibrils; the longitudinal splitting occurs readily in aqueous suspension, particularly if surfactants are used.

In laboratory preparations of pure chrysotile (Chatfield 1983a, 1985a; Burdett 1986e), it has been shown that the effects of indirect preparation on the longitudinal subdivision of long fibers can be minimized so that the important "index of exposure" of PCM-equivalent asbestos fibers can be estimated with less than a factor of two increase. It is not known whether this observation is widely applicable in a variety of occupational and environmental situations, where the asbestos is often present in matrices. However, if it is applicable, it would allow greater flexibility in the long-term sampling of buildings and outdoor environments, and also of short-term peak events (Sébastien et al. 1986; Guillemin et al. 1989; Kohyama 1989).

Data based on laboratory suspensions of pure chrysotile asbestos show that the fiber size distribution may be greatly affected by the indirect preparation procedures. When this occurs, the main effect of the indirect procedure is to greatly increase the number of fibers counted below 2.5 µm in length. The magnitude of this effect depends on the type of asbestos, the nature of the ACMs present, and the nature of the preparation method. Chatfield (1983a) reported a factor of five increase in the total number of fibers. Chatfield (1985a) showed that for pure commercial chrysotile from a vibrating bed generator, fiber counts of structures below 0.5 µm in length increased by a factor of 17 and in the 0.5 to 1.0 µm length range by a factor of 9, but reduced to 1.6 in the 2.5 to 5.0 µm range. Burdett (1986e) used similar samples and found that even when care was taken to minimize the disruption, a factor of six increase in fibers longer than 0.5 µm was possible. Similar increases, using environmental samples collected in mining regions of Quebec, have been reported by Sébastien and colleagues (1984). It is important to note that much larger increases in fiber numbers by the indirect preparation methods will occur across the whole range of fiber lengths if surfactant and strong mechanical agitation treatments are used.

A few studies have made comparisons between the direct and indirect methods using actual building samples. These were recently reviewed by Chesson and associates (1990a), who reported increases in the total numbers of fibers ranging from 3.8 to 1670 times, but who commented that both the analytical protocols and the nature of the asbestos varied within these studies. Only two of the studies reported by Chesson and associates provided fiber size information, but both indicated increases in the numbers of fibers longer than 5 µm when samples were prepared by indirect methods. In the reanalysis of samples from the GSA study (Chesson et al. 1990b), there appeared to be an approximately constant increase in chrysotile structures by a factor of 9-18 times across all lengths. In contrast to the situation for chrysotile, the amphibole asbestos counts did not change. Amphibole

of current exposures and the resulting need for remediation to reduce them most often focuses on C2 and C3 workers.

There are two basic options for remediation: (1) The ACM can be maintained in place with an O&M program, or (2) The ACM can be dealt with through direct abatement procedures including encapsulation, enclosure, or removal. These procedures may be applied alone or in combination.

5.1 Review of Methods to Survey ACM in Buildings

The first stage of any remediation plan is to carry out a survey to catalogue the type, quantity, condition, and location of all ACM in the building (EPA 1985a, 1990a; Conservation Foundation 1990; Greenaway 1986). The level of detail of the survey will depend upon the specific information required. Records about ACM in a building are often inadequate or incomplete, so field investigation of some sort is usually required. Samples from building materials must be analyzed for asbestos by a reliable laboratory using recognized techniques such as polarized light microscopy (PLM) and x-ray diffraction (XRD) (see section 4.4.4, Bulk Sampling and Analysis), or else be assumed to contain asbestos. Surveys fall into one of the following categories: visual survey (questionnaire), real property transfer survey, system survey, space-by-space survey, and renovation, repair, or predemolition surveys.

The *visual survey* (questionnaire) makes maximum use of existing knowledge about a building in order to minimize costs. It is aimed at making a general determination of what types of ACM are likely to be present. An individual with detailed knowledge of the facility compares his or her knowledge of the materials found in the building's systems against a list of materials that typically contain asbestos (Conservation Foundation 1990; EPA 1990b; Low and Mealey 1990; Real Estate position 1990). Suspect materials, rather than being tested, are assumed to contain asbestos. This type of survey may require little or no specialized knowledge about asbestos in buildings, and as such may minimize the need for trained consultants. The visual survey may be used as the basis for a more complete survey.

A *real property transfer survey* provides general information about the quantity and extent of friable ACM in a facility. This survey is intended to provide sufficient information to fulfill the legal requirements of real property transfer and to evaluate the likely economic impact of the presence of ACM on the market value of the facility. This survey is often based primarily on information the owner has about the facility. Individual building systems may or may not be identified.

A *system survey* identifies specific building systems (for example, hot- or cold-water pipe insulation or fireproofing) that include ACM. Such systems are catalogued, but their location throughout the facility is not necessarily determined. This type of survey provides the minimum information required to notify workers and contractors of the presence of ACM in the building. To be effective, this notification depends on each person's knowledge of the locations of the identified systems and understanding of the O&M procedures required if he or she comes into contact with ACM.

A *space-by-space survey* is the comprehensive survey envisioned by the Asbestos Hazard Emergency Response Act (AHERA) regulation (EPA 1987) for school facilities. The survey's aim is to document compositional information about the ACM located in a facility on a space-by-space basis. Each building system or product that contains asbestos is identified, its composition including asbestos and other components is determined, and its

accessibility, condition, and quantity are catalogued by location. The information provided facilitates the development of comprehensive remediation schemes. To save the cost of sample analysis, an asbestos content may be assumed for nonfriable materials that are unlikely to be broken up and made friable in normal use (such as resilient flooring, plaster, and drywall taping compound).

Renovation, repair, and predemolition surveys provide information about the asbestos content of all building materials that are likely to be disturbed by planned work. Both friable and nonfriable materials are sampled during these surveys, and their asbestos content is determined.

Other procedures listed below are sometimes used to gather extra information about a building. Although such investigations do not generate the kind of information gathered through the approaches described above, they provide additional information that can be helpful in making an assessment of the appropriate remediation techniques required for a given building.

An *air sampling survey* develops information on airborne concentrations of asbestos in the atmosphere of a facility. As discussed in section 4.4.1 (Air Sampling Strategies), depending on the design of the sampling program, an air sampling survey can describe personal occupational exposures, air concentrations under conditions at the specific time of the sampling, or, with sufficient coverage over space and time, the long-term ambient air concentrations representative of C1 exposures. Air sampling may also be used to assess the effectiveness of control procedures. In the absence of other indicators, a comprehensive air sampling survey evaluating exposures of C1, C2, and C3 occupants may show the need for remediation. Care must be taken to accurately determine episodic exposures for all groups.

Surface dust evaluation surveys assess the asbestos content of surface dust and debris. A variety of sampling methods have been used (see section 4.4.3, Surface Dust Sampling and Analysis) to collect samples from carpets, fabrics, and horizontal surfaces such as furniture, floors, and shelves. Results have been reported as the number of asbestos structures per unit surface area, mass per unit surface area, or as a percentage concentration in the dust (usually after indirect sample preparation). The concentrations are usually compared with those obtained from control surfaces. Surface dust evaluation provides information that can be useful in determining the priority for and type of remediation required, and in helping to determine if settled dust should be subject to remediation. Surface sampling can also be used to verify surface cleanliness following a decontamination procedure. A surface dust survey should be accompanied by a thorough visual inspection and PLM analysis of suspect debris. The relationship between asbestos in surface dust and either past or present inhalable airborne asbestos concentrations is difficult to evaluate (see section 4.5.3.1, Resuspension of Surface Dust: Interpretational Considerations). However, dustfall samples can be used to determine the spatial and temporal distribution of current asbestos particle deposition with collecting plates placed in the areas of interest. Analysis of the dust collected after a known period of time can provide information on the sources of release.

5.2 Review of Assessment Methods

Assessment refers to various methods customarily used for determining whether remediation is necessary and, if so, what form of remediation is appropriate and in what priority. The EPA, in its current guidance documents (EPA 1985a, 1990a) and in the final rule promulgated under AHERA, states that an O&M program is always necessary where ACM is found (EPA 1987). It should be noted that AHERA regulations apply only to schools; thus, under AHERA, assessment involves only setting priorities and selecting